Preliminary Paper on the Babylonian Astronomy.

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The Calendar.

The progress of the decipherment of the Inscriptions of Assyria and Babylon has rendered it possible to develop with some certainty the fundamental principles of the Astronomy of those ancient nations. We are at present engaged in the study of the Babylonian Astronomy; and we desire to state that we have obtained certain results, and to give some indication of their nature.

The first question is, What was the nature of the Babylonian Calendar, and how did it depend on the motions of the heavenly bodies? Of this question we have been able to obtain a solution of an apparently complete nature. So far as we are aware, this calendar has never been discussed before; and it is as remarkable for its theoretical elegance as for its practical simplicity and historic interest. We do not say that every passage in the inscriptions harmonises with this calendar. Many of the inscriptions are very obscure; many are hopelessly corrupt copies of earlier ones; and many contain accounts of phenomena which are absolutely impossible on any hypothesis whatever. Under these circumstances the discussion of the evidence of the inscriptions is a matter requiring care and caution. But there is in our minds no doubt worth consideration that the calendar in question was substantially the calendar of those who wrote the inscriptions.

In the present paper we propose to quote a few of the principal passages on which the establishment of the calendar rests, and to give some account of it. Other subjects, such as the identification of stars, the measurement of longitude, and the treatment of the evidence generally, must await another opportunity.

First, we must premise that the inscriptions are written in at least two languages, Assyrian and Accadian; and everything has in consequence two names at least, though these are generally represented by the same character. The planets also frequently assume the names of stars in whose neighbourhood they were observed. For the present we will only take the case of the star *Icu* or *Dilgan*, which appears to have been the foundation of the calendar in question. It was called *Dilgan*, or 'the messenger of light,'' in Accadian, and "Icu of Babylon" in Assyrian. The object of mentioning this is to explain how it is that the two names are used indifferently.

The following are the principal passages connecting this star with the beginning of the year.

In the reverse of the Catalogue, or Preface, of the *Illumi-*

nation of Bel (the great ancient astronomical work of Babylon), there occurs this passage, among the general enumeration of the phenomena and the astronomer's duties :—

"The appearance at the beginning of the year of the star *Icu*, ... one observes."

On the colophon of a tablet containing an enumeration of the stars of certain months there occurs, by way of contents, what is supposed to be the first line of the next tablet; it runs :—

"The star *Icu* in the month Nisan was seen."

The language of these two inscriptions is Semitic. They belong, however, to an ancient work compiled for Sargon of Agané about 1700 B.C.

These two passages prepare us to find that the definition of time by a star consists in its appearing; whereas it has commonly been supposed that the definition of time by a star consists in its disappearing behind the Sun.

The only kind of annual appearing that stars perform, for the purposes of those who watch all night, is their heliacal rising, or issuing forth from the region of the Sun before sunrise The frequent mention of the rising of stars confirms us in the opinion that the heliacal rising was the phenomenon by which they were chiefly classified. We were therefore prepared by these passages to find that the beginning of the year was regulated by the heliacal rising of some star.

The following passage now requires consideration: "When on the first day of the month Nisan the star of stars (or *Dilgan*) and the Moon are parallel, that year is normal. When on the third day of the month Nisan the star of stars and the Moon are parallel, that year is full" (i.e. has 13 months).

This inscription is in Accadian, the most ancient language of the inscriptions. It may be expected to belong to a time earlier than 2000 B.C.

On considering this inscription from the point of view of modern astronomy, it becomes evident that we have here the key to the calendar, if we can only ascertain definitely that the months were lunar months; so that the beginning of the year could be defined by the Moon. As there is some difficulty about this point, it is necessary to consider it a little.

The following passage occurs in the Preface or Catalogue before mentioned :—

"12 months to each year, ($6 \times 60 =$) 360 days, in order are recorded by the hand . . . ."

If this was accurate, the months could not be lunar. But it is abundantly clear that they were lunar. The more recent inscriptions are the clearest on this point. They record cases of watching for the Moon at the end of the month.

The notices of eclipses throughout the inscriptions serve to confirm this conclusion. The eclipses of the Moon were generally observed about the 14th day, and those of the Sun from the

28th to the 30th. In some of the ancient astrological tablets there are collocations of observations of eclipses which present difficulties; but these still recur month after month on the same days, so that the lunar determination of the month is preserved throughout.

Further, the names of these months are substantially those of the lunar calendar of the Jews. It is therefore to be expected that the determination of the beginnings of the months will be found to be effected according to the custom of that calendar, which is by the observation of the first visible appearance of the new Moon.

(For a description of the Jewish custom *see* Disraeli's *Alroy*, Part x. ch. 1, "We are the watchers of the Moon, to tell the nation that the month begins.")

There is only one way of reconciling the calendar of lunar months with the statement as to the year of 360 days. The mean synodic lunation being about $29\frac{1}{2}^d$, the real length would often be 30^d. We must suppose that the reckoning up of the 12 sets of 30 days to the total of 360^d was the work of a commentator, or perhaps of an inaccurate writer or copyist. We have, in other parts of these tablets, examples of statements undoubtedly incorrect, which are to be ascribed to similar causes.

In order, however, to ascertain the possibility of working a lunar calendar according to the rule of 360 days, we have discussed the calendar thus resulting. And we find that undoubtedly a calendar of 360 days in the year can be worked approximately by lunar methods; but the rule on which the working of such a calendar would depend would be entirely different from that given in the inscriptions; while, the months being of 30 days, and not lunar months, the watchings for the new Moon and the eclipses would occur irregularly on all the different days of the month. And this would be contrary to what we find in the inscriptions.*

Assuming then that the months were lunar, and began with the first visible appearance of the new Moon, we proceed to deduce the nature of the calendar arising from the rule above quoted, viz.:—

"When on 1 Nisan the star of stars and the Moon are parallel, that year is normal. When on 3 Nisan the star of stars and the Moon are parallel, that year is full," i.e. has 13 months. We will first consider this rule independently of anything else,

* We may just mention that the lunar rule of the calendar of 360^d would depend on the fact that this period exceeds the lunar year of 12 lunations by the same amount, roughly, by which it falls short of the solar year; so that the lunar intercalary months would accumulate approximately at the same rate as those required to make up the solar year.

In fact

$$\begin{aligned} 360^d &= 12 \text{ mean lunations} + 5^d{\cdot}633 \\ &= 1 \text{ tropical year} \quad - 5{\cdot}242 \end{aligned}$$

and afterwards take up its relation to the equinox, and the heliacal rising of the same star (*Dilgan* or *Icu*) at the beginning of the year.

We will consider this relation, "when the Moon is parallel to the star of stars," as defining a point on the ecliptic, which we will regard as the origin of longitudé. And we will speak of longitude thus measured as "longitude from *Icu*." It will be positive when measured in the usual direction, from W. to E., and negative in the opposite direction.

Assume further, for small distances from *Icu*, that the Moon's mean distance from the Sun is 12° for each day from new Moon; that the Sun's daily motion is 1°; and the Moon's daily motion 13°.

The new Moon is said to be visible under the most favourable circumstances 18 hours after conjunction. The probable cases would therefore be included between the limits 18 and 42 hours after conjunction. We assume 30 hours for the mean time ot visibility after conjunction.

In the mean normal year of the rule the Moon is, then, parallel to *Icu* on 1 Nisan, 30 hours after conjunction, or at a distance of 15° from the Sun. Hence,

Sun's longitude from *Icu* on 1 Nisan in the normal year is − 15°.

In the "full year" of the rule the Moon is parallel to *Icu* on 3 Nisan, or in the mean $3\frac{1}{4}^{d}$ from the Sun. Hence,

Sun's longitude from *Icu* on 3 Nisan mean full year = −39°;

and, according to the rule, when the Sun is as much as this behind *Icu* on 3 Nisan an intercalary month is due at the end of the year.

The most remarkable thing about the rule so far is the way in which the Moon is used as a mere pointer in the sky, for measuring the distance from the Sun to a fixed point among the stars. For the comprehension of the actual working of this rule in each separate case, as above, nothing is needed but the very roughest knowledge of the Moon's mean motion for a few days. Without going any further, we see that the rule secures on the average an accurate sidereal year. For whenever the Sun, at the beginning of the year, has slipped more than a certain distance from a fixed point among the stars, an intercalary month is added to bring him up again.

We will now form the table of the succession of the years, and the introduction of the intercalary months, according to the approximate mean rule of lunations used in modern calendars.

According to this approximation, $1^{y} - 11^{d} = 12$ lunations. We can enumerate all the possible cases conveniently by supposing that the years succeed each other in the order thus determined, without return after the 19 years period. We can then always find some part of the table which shall approximately represent a given case.

As the lunar years are too short, let the Moon of 1 Nisan come x days too soon in the general case. Then x is a number

similar to the epact of modern calendars, and the Sun will be x° behind his place in the normal year. Then,

			1 Nisan. °	3 Nisan. °
Normal Year	Longitude from *Icu*	Moon	0	26
"	" "	Sun	-15	-13
General Year	" "	Sun	$-(15+x)$	$-(13+x)$
"	" "	Moon	$-x$	$26-x$

since the mean distances of the Sun and Moon on 1 and 3 Nisan are 15° and 39° respectively.

Table of the cases of the Babylonian Calendar, arranged in the order shown by a mean calendar Moon, without return after 19 *years period.*

	Sidereal years. y		Days over. d ($-x$)		Intercalary month. ($-x$)		Lunar years.	At the beginning of following year. Moon's longitude from *Icu.* 3 Nisan $=26^\circ-x^\circ$. °	At the beginning of following year. Intercalary Due at 7°.
Normal Year	1	—	11			=	1	15	
	2	—	22			=	2	4	I. D.
	3	—	33	+	30	=	3	23	
	4	—	14			=	4	12	
	5	—	25			=	5	1	I. D.
	6	—	36	+	30	=	6	20	
	7	—	17			=	7	9	
	8	—	28			=	8	−2	I. D.
	9	—	39	+	30	=	9	17	
	10	—	20			=	10	6	I. D.
	11	—	31	+	30	=	11	25	
	12	—	12			=	12	14	
	13	—	23			=	13	3	I. D.
	14	—	34	+	30	=	14	22	
	15	—	15			=	15	11	
	16	—	26			=	16	0	I. D.
	17	—	37	+	30	=	17	19	
	18	—	18			=	18	8	
	19	—	29			=	19	−3	I. D.
	20	—	40	+	30	=	20	16	
	21	—	21			=	21	5	I. D.
	22	—	32	+	30	=	22	24	
	23	—	13			=	23	13	
	24	—	24			=	24	2	I. D.
	25	—	35	+	30	=	25	21	
	26	—	16			=	26	10	
	27	—	27			=	27	−1	I. D.
	28	—	38	+	30	=	28	18	
	29	—	19			=	29	7	I. D.
	30	—	30	+	30	=	30	26	

The rule for the intercalary month says, "when the Moon is parallel to *Icu* on the 3rd Nisan." But since the Moon moves through about 13° each day, we must admit half a day's journey, say 6° or 7°, to come within the rule.

And we must take 7° at least. For if we do not, the condition of the normal year can never recur; i.e. the parallelism to *Icu* on the 1st Nisan, or $x = 0$. We see from years 29 and 30 of the table that this happens when the longitude from *Icu* on 3 Nisan is 7° the year before, and the intercalary is then due. Of course it is not probable that the rule was worked to a single degree in this way; but for calculation we must draw the line somewhere, and we select 7° as the limit for the above reasons. It is remarkable that this rule of intercalaries leads to a series of values for x which are in all respects comparable with the epacts of the ecclesiastical calendars.

It will be seen that the values of x vary from 0 in the normal year to 29 in the 19th year of the series. That is to say, the Sun is always later than in the normal year, and may be as much as 29 days later. This is obviously a property of any calendar regulated by intercalary months; every true annual occurrence must be liable to an apparent oscillation of date amounting to the inside of a month.

So far we have said nothing about equinoxes; we have established the calendar, in accordance with the rule of the inscriptions, on a purely sidereal basis. We can now proceed to consider the probable position, with respect to the equinox, of our starting place—the point marked on the ecliptic as parallel to the star of stars.

There is reason to believe that the mean date of the equinox was not far from the beginning of Nisan. If we assume for the mean year No. 15 of the table, in which the Sun is 15° behind the normal position, or midway between its extreme positions, we have for the Sun's longitude from *Icu* on 1 Nisan, −30°. At the date of the establishment of the calendar, we may therefore expect to find the equinox about 30° behind the star *Icu*, or the star *Icu* about 30° in front of the equinox, with some considerable latitude either way. (For we cannot be sure that the mean position of the equinox would coincide with 1 Nisan, within 15 days or more either way.)

It is generally admitted that the establishment of this calendar is to be looked for about 2000 B.C. We select the number of 3,960 years, equivalent to 55° of precession, and seek for a star which was in longitude $30° \pm 15°$ about 3,960 years ago; we seek especially for any star of the first magnitude which also satisfies the condition of rising heliacally about the time of the new year. There is no doubt about the result. The star *Capella* is the only star that satisfies these conditions; and numerous independent lines of evidence converge to identify it with *Icu*. It rose heliacally at the period in question before it set; its large north latitude, 22° 51′ 45″ (Delambre), or 23° nearly, throwing it up in the

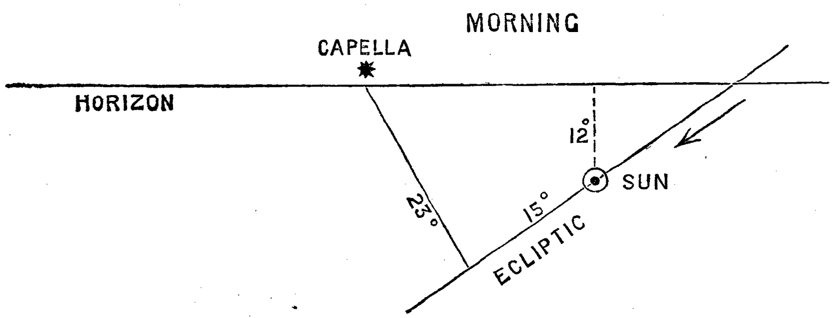
morning, at the vernal equinox, when the ecliptic has its least inclination to the horizon.

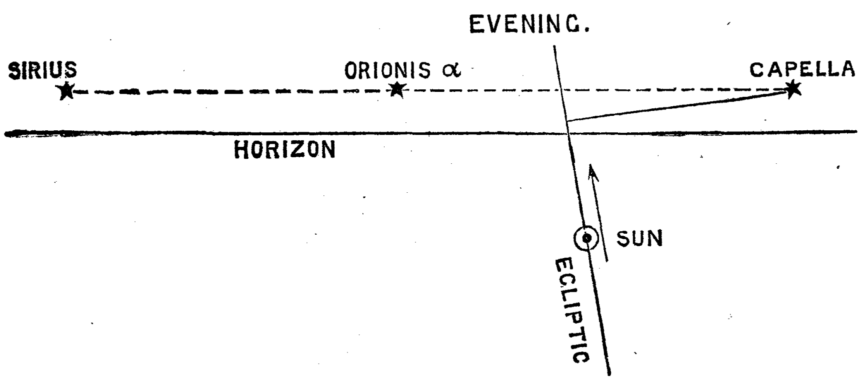
The identification was effected by means of a celestial globe, on which the positions of the principal stars have been laid down for the period in question, referred to the equator and ecliptic of the globe as the equator and ecliptic of the period. But the following calculation exhibits the result as to the longitude:—

	°	′	″
Longitude of *Capella* with regard to *Regulus* (Delambre)	292	0	40
Longitude of *Regulus*, 1840, Airy (Smyth's Cycle)	147	36	20
	439	37	0
	360	0	0
	79	37	0
Precession	55	0	0
Longitude of *Capella* 2120 B.C.	24	37	0

The latitude of Babylon may be taken at $32\frac{1}{2}°$. We have generally solved the problem of the heliacal rising approximately

→ = + longitude direction.





by means of the globe. And considering the vagueness of our information about the phenomenon itself, we think perhaps that this method is near enough for the purpose. Assuming that a 1^m star rises heliacally when it is 12° in direct altitude above the

Sun at the horizon, we find that *Capella* rose heliacally when the Sun was about 15° short of the star in longitude. But this is the position of the Sun on 1 Nisan in the normal year, subject to a small correction. So that the coincidence of the beginning of the year with the rising of *Icu* is fairly satisfied by the position of *Capella* at the given date.

To explain the occurrence of these different phenomena at morning and evening, at the same time of the year, we subjoin the following figures, which represent roughly the appearance of the quarters of the sky in the neighbourhood of the rising and setting Sun respectively at this time.

The evening position, "parallel to *Capella*," for a body moving in the ecliptic, is marked by a nearly level line of stars at about the same altitude, the other chief stars being α *Orionis* and *Sirius*. This line cuts the ecliptic some 3° above the foot of the latitude perpendicular from *Capella*.

The intersection of this horizontal line with the ecliptic is possibly to be regarded as the true starting-point of the calendar. The allowance, to be added to the equinoctial longitude of *Capella* on this account, varies a little with the change of position of the starry sphere; but it is not far from 3° within somewhat wide limits, both of precession and diurnal motion.

Then the longitude of the point "parallel to *Icu*" would be *Capella's* longitude $+ 3° = 27\frac{1}{2}°$ say. Whence

1 Nisan	Sun's longitude in normal year	=	$12\frac{1}{2}°$	{from Equinox 2120 B.C.}
	" " mean year	=	$-2\frac{1}{2}$	
	" " latest year	=	$-16\frac{1}{2}$	

and

			d
Earliest equinox	=	$-12\frac{1}{2}$	Nisan
	(=	$17\frac{1}{2}$	Adar)
Mean "	=	$2\frac{1}{2}$	Nisan
Latest "	=	$16\frac{1}{2}$	"

The equinox will vary with the date, being earlier for later dates and later for earlier dates, to the extent of 1^{d} for every 71 years nearly.

In the present paper we have explained the most essential parts of our conclusions as to the Babylonian Calendar. We hope, on a future occasion, to discuss other portions of the Babylonian Astronomy.